21. Suzuki S, Osborne JW, Leinfelder KF. Preclinical screening test for evaluating posterior composite resin wear. J Esthet Dent 1996; 8:263–268.

22. Suzuki S, Suzuki SH, Cox CF. Evaluating the antagonistic wear of restorative materials when placed against human enamel. J Am Dent Assoc 1996; 127:74–80.

23. Condon JR, Ferracane JL. Evaluation of composite wear with a new multi-mode oral wear simulator. Dent Mater 1996; 12: 218–226.

24. Leinfelder KF, Suzuki S. In vitro wear device for determining posterior composite wear. J Am Dent Assoc 1999; 130: 1347–1353.

25. Yap AUJ, Ong LFKL, Teo SH, Hastings GW. Comparative wear ranking of dental restoratives with the BIOMAT wear simulator. J Oral Rehabil 1999; 26:228–235.

26. Manhart J, Kunzelmann KH, Chen HY, Hickel R. Mechanical properties of new composite restorative materials. J Biomed Mater Res 2000; 53:353–361.

27. Hu X, Marquis PM, Shortall AC. Two-body in vitro wear study of some current dental composites and amalgams. J Prosthet Dent 1999; 82:214–220.

28. ADA Council on Scientific Affairs. Acceptance program guidelines for resin based composites for posterior restorations. Chicago: ADA Publishing, 2001.

29. Perry R, Kugel G, Leinfelder KF. One-year clinical evaluation of SureFil packable composite. Compendium 1999; 20: 544–553.

30. Bayne SC, Taylor DF, Heymann HO. Protection hypothesis for composite wear. Dent Mater 1992; 8:305–309.

31. Choi KK, Feracane JF, Hilton TJ, Charlton D. Properties of packable dental composites. J Esthet Dent 2000; 12:216–226.

32. Ferracane JL, Choi KK, Condon JR. In vitro wear of packable dental composites. Compend Contin Educ Dent 1999; 25(Suppl): 60–66.

33. Ramp MH, Suzuki S, Cox CF, Lacefield WR, Koth DL. Evaluation of wear: enamel opposing three ceramic materials and a gold alloy. J Prosthet Dent 1997; 77: 523–530.

34. Young HL, Suzuki S. Wear of composite resin inlays and antagonistic enamel. Am J Dent 1999; 12:47–50.

35. Imai Y, Suzuki S, Fukushima S. Enamel wear of modified porcelains. Am J Dent 2000; 13:315–323.

36. Soderholm KJM. Filler systems and resin interface. In: Vanaherle G, Smith DC, eds. Posterior composite resin dental restorative materials. Amsterdam, Netherland: Peter Szule Publishing, 1985:501–509.

37. Suzuki S, Leinfelder KF, Kawai K, Tsuchitani Y. Effect of particle variation on wear rates of posterior composites. Am J Dent 1995; 8:173–179.

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COMMENTARY

DOES THE WEAR RESISTANCE OF PACKABLE COMPOSITE EQUAL THAT OF DENTAL AMALGAM?

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Clinically, the questions in most peoples' mind regarding the value of packable or other posterior composite restorations versus dental amalgams involve (1) secondary caries resistance, (2) wear resistance, (3) resistance to intraoral degradation, and (4) bulk fracture resistance. Everything else is probably trivial if posterior composite restorations are well placed. Frequently, the concern for postoperative sensitivity is mentioned, but the actual incidence appears to be very low for well-placed restorations that do not involve a deep proximal box in the preparation design.

Resistance to dental caries depends almost exclusively on the success of the bonding system used with the composite and not on the composite per se. One must be cautious when interpreting clinical research results. Dental caries associated with tooth-colored materials has been reported to occur 94% of the time in clinical practice when associated with proximal margins.[1]

Wear resistance is a fickle property. It depends on several factors: (1) type of loading events, (2) width of restoration, and (3) intraoral location. Only some of these are measured in laboratory simulations or clinical research trial designs. There are probably five distinct types of loading events: contact-free or food bolus wear, occlusal contact area wear,

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functional contact area wear, proximal contact area wear, and toothbrush or dentifrice abrasion.[2] Suzuki has attempted to consider two of these events in the current study that involves the food bolus (contact-free wear) or cusp effects (contact area wear) on occlusal surfaces. Contact-free wear is simulated in a Leinfelder wear apparatus by using a Delrin stylus to push an artificial food bolus onto a restorative material. In a modification of the setup, the apparatus has been equipped with a stainless steel or enamel stylus to contact the restoration to simulate occlusal contact, functional contact, and proximal contact wear as well. Although the differences in potential mechanisms are not well known, the processes do differ in patterns and extents.

One of the shortcomings of wear simulators is that the equipment is designed to maintain contact between the stylus and the material being tested. In many clinical situations, contact does not persist after some wear occurs. This point has been demonstrated by differences between the wear rates that occur with simulators and those that are seen in actual clinical practice. With wear simulators, the wear occurs essentially in a linear way over time (or number of cycles) so that the wear rate is constant. Clinically, as loss of contact occurs and wear starts to diminish, the wear rate typically drops to a very low rate.[3]

Another caution for wear research is that the behavior of the controls in simulators may not mimic the behavior clinically. Dental amalgam does wear, and those rates are detected in simulators. However, little or no net wear is observed clinically on occlusal surfaces of restorations because there is a balance between slow and continuing expansion and occlusal attrition. On proximal surfaces, however, wear is much lower and amalgam expansion dominates.[2]

Packable composites are intended to be able supplant amalgam in all situations, including those with wide occlusal portions and/or cusp-capping extensions on molar teeth. Wider restorations are certainly more susceptible to stress and contact with the food bolus. In ongoing clinical trials, that comply with amalgam-replacement guidelines established by the American Dental Association,[4] there is already good evidence that certain packable materials are doing well in short-term clinical trials.[5–7] Results from the current investigation by Suzuki seem to agree with these clinical trends and with early laboratory predictions for SureFil versus other packable composites.[8] Not all packable materials have shown good laboratory or clinical performance. Solitaire is a good example.[9,10]

It is important to understand that one of the key unanswered clinical questions is whether low and high wear rates for posterior composites will lead to different amounts of total wear after 10 to 20 years. Composites with relatively poor wear resistance that are placed in narrow-width cavity preparations wear quickly during the first 3 to 5 years, and then wear dramatically slows down.[11] Wear during the following 5 to 17 years appears to be almost nonexistent. This is explained by the fact that after some wear has taken place, the enamel margins begin to shelter the remaining restorative surface and prevent further abrasive action of the food bolus (ie, macroprotection[12]). More wear-resistant materials undergo wear at slower rates but may still wear to the same levels before sheltering begins. Sheltering probably disappears with very wide or cusp-capping restorations. At present there is no information that describes the relative effects of the food bolus. Presumably the loss of some occlusal contacts and the absence of effective food bolus compression on the surfaces may protect these surfaces to some degree. The first evidence from clinical trials for wear-resistant materials such as SureFil and Alert seem to support this premise. Results from the present research study by Suzuki help to rank differences of materials depending on the type of antagonist that might be present in more aggressive wear situations. It will be interesting to see how 5- to 10-year results for packables compare with the results presented here.

There is evidence that posterior composites undergo intraoral degradation including chemical deterioration owing to esterases.[13–21] Even though this contribution may be relatively small, currently these events are not well understood and deserve more careful attention. These degradation events are not simulated by laboratory wear machines but could accelerate actual clinical wear rates. Beyond esterase effects, there is evidence of instability of certain composite components in high pH environments. Sarkar and Karmaker have demonstrated this instability for composites exposed to NaOH solutions.[22,23]

Bulk fracture resistance is probably not as high as composite formulators might desire (toughness values range from approximately 1.5 to 2.5 MPa-m$^{1/2}$), but the resistance is not significantly worse than that of dental amalgam. Most long-lived dental amalgams ultimately fail by bulk fracture and not secondary caries.[24]

Although the experiment by Suzuki provides good information about wear resistance, much more information needs to be determined about aspects such as fracture resistance before the final pronouncement can be made that packable composites are equal in all ways to dental amalgam.

REFERENCES

1. Mjor IA. Frequency of secondary caries at various anatomical locations. Oper Dent 1985; 10:88–92.
2. Bayne SC, Thompson JY, Taylor DF. Dental materials. In: Roberson TM, ed. Sturdevant's art and science of operative dentistry. 4th Ed. St. Louis: Mosby; 2001:204–205.
3. Sturdevant JR, Lundeen TF, Sluder TB, et al. Five-year study of two light-cured posterior composite resins. Dent Mater 1988; 4:105–110.
4. American Dental Association. Guidelines for clinical trials for posterior composites. Chicago: American Dental Association Council on Scientific Affairs, 2001.
5. Perry RD, Kugel G. Two-year clinical evaluation of a high-density posterior restorative material. Compend Contin Educ Dent 2000; 12: 1067–1076.
6. Wilder AD, Bayne SC, Perdigao J, et al. 5-year clinical performance of packable posterior composite. J Dent Res 2004; 83. (Abstr 0550)
7. Clelland NL, Villarroel SC, Knobloch LA, Seghi RR. Simulated oral wear of packable composites. Oper Dent 2003; 28:830–837.
8. Ruddell DE, Thompson JY, Stamatiades PJ, et al. Mechanical properties and wear behavior of condensable composites. J Dent Res 1999; 78:156. (Abstr)
9. Ernst CP, Martin M, Stuff S, Willershausen B. Clinical performance of a packable resin composite for posterior teeth after 3 years. Clin Oral Investig 2001; 5:148–155.
10. Oberlander H, Hiller KA, Thonemann B, Schmalz G. Clinical evaluation of packable composite resins in Class-II restorations. Clin Oral Investig 2001; 5:102–107.
11. Wilder AD, May KN, Bayne SC, et al. Seventeen-year clinical study of ultraviolet-cured posterior composite Class I and II restorations. J Esthet Dent 1999; 11:135–142.
12. Bayne SC, Taylor DF, Heymann HO. Protection hypothesis for composite wear. Dent Mater 1992; 8:305–309.
13. Finer Y, Santerre JP. The influence of resin chemistry on a dental composite's biodegradation. J Biomed Mater Res 2004; 69A:233–246.
14. Finer Y, Santerre JP. Salivary esterase activity and its association with the biodegradation of dental composites. J Dent Res 2004; 83:22–26.
15. Jaffer F, Finer Y, Santerre JP. Mutual influence of cholesterol esterase and pseudocholinesterase on the biodegradation of dental composites. Biomaterials 2004; 25:1787–1793.
16. Finer Y, Santerre JP. Biodegradation of a dental composite by esterases: dependence on enzyme concentration and specificity. J Biomater Sci Polym Ed 2003; 14:837–849.
17. Jaffer F, Finer Y, Santerre JP. Interactions between resin monomers and commercial composite resins with human saliva derived esterases. Biomaterials 2002; 23:1707–1719.
18. Santerre JP, Shajii L, Tsang H. Biodegradation of commercial dental composites by cholesterol esterase. J Dent Res 1999; 78:1459–1468.
19. de Gee AJ, Wendt SL, Werner A, Davidson CL. Influence of enzymes and plaque acids on in vitro wear of dental composites. Biomaterials 1996; 17:1327–1332.
20. Larsen IB, Munksgaard EC. Effect of human saliva on surface degradation of composite resins. Scand J Dent Res 1991; 99:254–261.
21. Freund M, Munksgaard EC. Enzymatic degradation of BISGMA/TEGDMA-polymers causing decreased microhardness and greater wear in vitro. Scand J Dent Res 1990; 98:352–355.
22. Sarkar NK. Internal corrosion in dental composite wear: its significance and simulation. Appl Biomater 2000; 53:371–380.
23. Sarkar NK, Karmaker A, Prasad A, Shih F. Simulation of in vivo degradation of dental composites. J Mater Sci Let 1999; 18:1749–1752.
24. Letzel H, van't Hof MA, Marshall GW, Marshall SJ. The influence of the amalgam alloy on the survival of amalgam restorations: a secondary analysis of multiple controlled clinical trials. J Dent Res 1997; 76:1787–1798.